[0020] **FIG. 5** shows one embodiment of this invention. Flexible membrane **12** comprises a flexible substrate **22**, suitably equipped with LEDs **24** and photo-sensors **26** facing toward base **16**. Flexible substrate **22** may be made of a suitable plastic. The photo-sensors may comprise phototransistors or photo diodes, for example. LEDs **24** and photo-sensors **26** are formed on substrate **22**. In this embodiment, the LEDs and photo-sensors are arranged in pairs (one LED and one photo-sensor per pair). The LED and photo-sensor of each pair are preferably located closely to one another. A durable wear surface **23** may be provided over substrate **22**.

[0021] **FIG. 6** shows a plan view of the device of **FIG. 5**. **FIG. 6** illustrates the arrangement of the LED/photo-sensor pairs schematically. It is preferred (but not required) that the LED/photo-sensor pairs be arranged in a generally regular row-column format, with the spacing between rows and columns (Δx and Δy) roughly equivalent. Each LED/photo-sensor pair constitutes electronic components of a pressure sensor. As shown in **FIG. 6**, a plurality of pressure sensors may be formed on flexible surface **12**. The optimum spacing depends on the desired accuracy of the device, with a greater number of sensors providing greater accuracy. The spacing (Δx and Δy) is preferably in the range of about 0.5 mm to about 25 mm, and is preferably about 5 mm if the application calls for detecting multiple touches from a finger.

[0022] The compressible elastic material **14**, in this case, is somewhat translucent. Material **14** has a large number of very small light-scattering centres. Material **14** may comprise, for example, a natural-coloured polyurethane foam, 1 mm to 6 mm thick, which has small bubbles which serve as the light-scattering centres. Light emitted from each of LEDs **24** enters material **14** and individual light rays reflect multiple times as they hit the scattering centres. This results in a so-called "optical cavity"**30** (**FIG. 5**) which is characterized by having fully scattered (isotropic) light. When flexible membrane **12** is deflected downward, the elastic material **14** compresses and the intensity of light measured by the photo-sensor **24** at the location is changed. Signals from photo-sensors **26** may be processed to determine the location(s) and magnitude(s) of one or more forces applied to flexible surface **12**. The use of this effect to measure deflection is described more fully in Reimer et al., PCT patent publication No. WO 99/04234 which is incorporated herein by reference. A reflective layer **32** may be provided on base **16**.

[0023] **FIG. 7***a* shows apparatus according to another embodiment of this invention. As before, LEDs **24** and photo-sensors **26** are deposited on a flexible plastic substrate **22** in pairs and located as shown in **FIG. 6**. In this case, however, the elastic material **14** is perforated so as not to directly underlie the LED/photo-sensor pairs. A reflective layer **32** is placed underneath elastic material **14**. Polymerized mylar is an example of a suitable material for layer **32**. As shown in **FIG. 7***b*, deflection of flexible membrane **12** causes the distance, z, between the LED/photo-sensor pair and reflective layer **32** at that location to lessen. Therefore the light detected by the photo-sensor **26** will change. Again, signals from photo-sensors **26** can be processed to determine the location(s) and magnitude(s) of forces applied to flexible membrane **12**.

[0024] In another embodiment of this invention, shown in **FIG. 7***c*, substrate **22** is outfitted with a number of micro-electronic strain gauges **36**. In this case, LEDs and photo-sensors are not required to measure the deflection of the membrane; output signals from strain gauges **36** provide a measure of the deflection of substrate **22**. These output signals can be processed to determine the location(s) and magnitude(s) of forces applied to flexible membrane **12**.

[0025] For all of the aspects of the invention described above, it is preferable to provide a signal processing unit. The signal processing unit monitors output signals from the sensors. The output signals are typically electrical signals output from the photo-sensors **26** or strain gauges **36**. The output voltages or currents of the sensors (be they any of those described above) are provided to the signal processing unit. The signal processing unit preferably includes at least one analog-to-digital convertor, current regulators for the LEDs (where necessary) and a digital processor. The digital processor preferably implements software which calibrates each sensor, and which computes the location of pressures applied to flexible membrane **12** by interpolation between nearby sensors.

[0026] Pressures applied at multiple points of contact may be simultaneously measured.

[0027] Some embodiments of the invention incorporate flexible displays onto the touch-sensitive surface. The displays may be implemented as an array of thin film transistors (TFTs) deposited on substrate **22**.

[0028] **FIG. 8** shows apparatus **40** which combines a display and a touch-sensitive surface according to one aspect of the invention. Apparatus **40** comprises a flexible display **42** on top of an underlying pressure sensitive surface **44**. For illustrative purposes, the underlying pressure sensitive surface is shown to have dimpled membrane **46**, a compressible elastic medium **14** and a base layer **16**. Pressure sensors (not shown) are embedded in the underlying pressure-sensitive surface. One novel feature of some embodiments of this invention is the combination of a flexible plastic substrate TFT display with a touch-sensitive surface.

[0029] It will be appreciated that the invention can be embodied according to various combinations and sub-combinations of the features described above. At a basic level, devices according to the invention comprise a flexible membrane on a resilient elastic material. Deflection sensors are disposed on the flexible surface. The deflection sensors measure the deflection of the flexible membrane and preferably comprise electronic devices/circuits which have been deposited directly onto the flexible surface. The flexible membrane may comprise a flexible membrane bearing the position sensors which has been laminated to the resilient elastic material.

[0030] In a preferred embodiment of the invention the deflection sensors comprise LED/photo-sensor pairs. The LED/photo-sensor pairs may produce output signals which depend on the changing intensity of light in an optical cavity or may produce output signals which vary with the proximity to a base layer. In alternative embodiments of the invention the deflection sensors comprise strain gauges on the flexible membrane. The strain gauges produce output signals which vary with strains in the flexible surface.

[0031] Some embodiments of the invention incorporate a display. The display may be laminated to an underlying pressure sensitive surface to yield a touch-sensitive display.